EXHIBIT 5-1
NITRATE AND RAINFALL CORRELATION

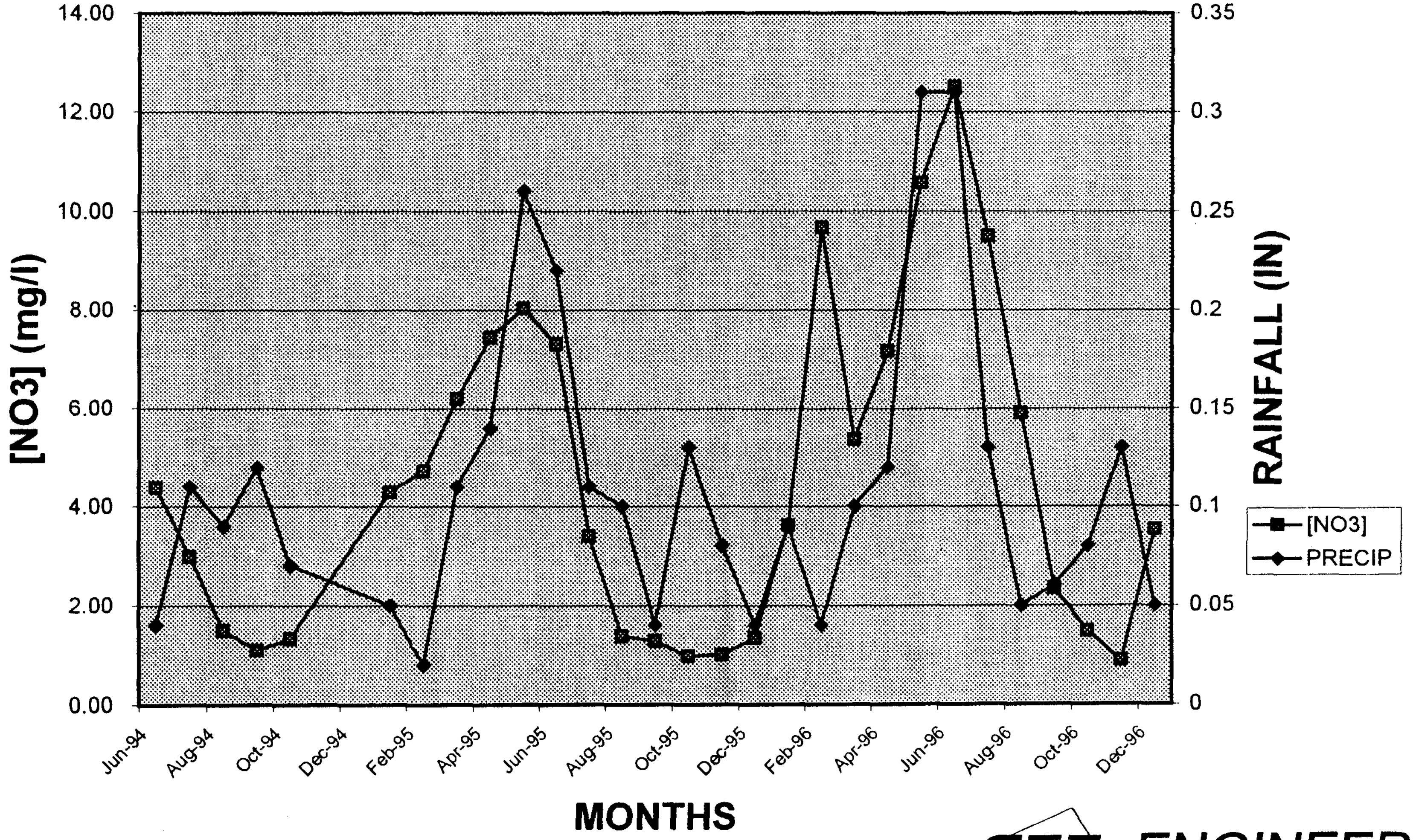

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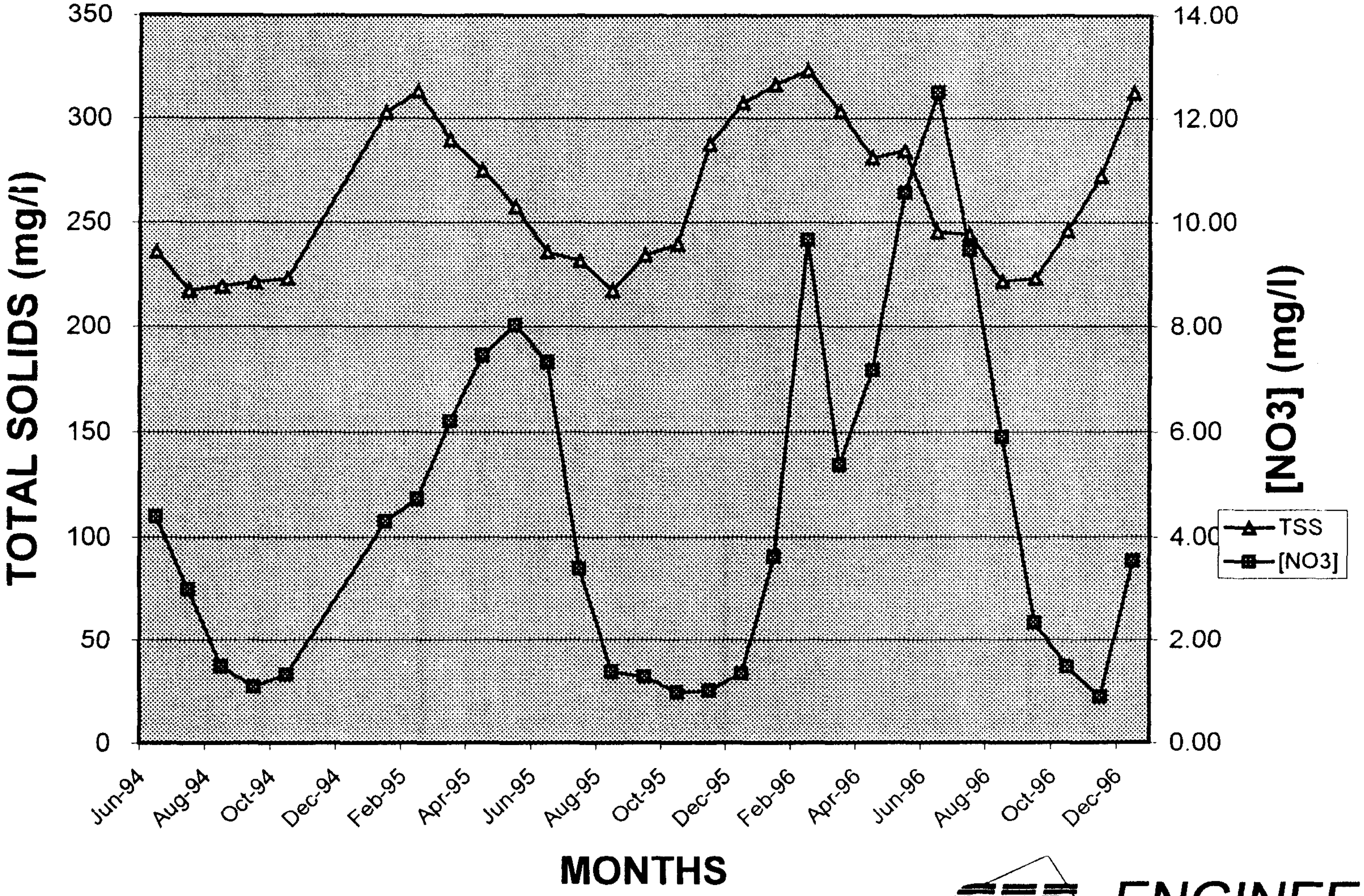
EXHIBIT 5-2
TOTAL SOLIDS AND NITRATE CORRELATION



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2. Synthetic Organic Chemicals

Like nitrates, synthetic organic chemicals (SOC's) make their way to Lake Vermilion from mostly agricultural sources. SOC's have occasionally been detected in the raw water but never at levels which trigger a violation. These chemicals are agricultural products such as atrazine, simazine and cyanazine, which are used as herbicides and pesticides in the watershed. Although these do not pose an immediate problem for the Water Company, they are consistently monitored.

To treat elevated levels of SOC's, CTE has evaluated and recommended that CIWC construct a new powdered activated carbon slurry system, which will provide them with three feed points from which they can apply the slurry. The cost of the new PAC system is included in Chapter 8 of this report with the cost analyses for each of the alternatives evaluated.

A. NEW REGULATIONS

1. Disinfectants/Disinfection Byproducts

The Stage 1 Disinfectants/Disinfection Byproducts Rule (D/DBPR) was published by the USEPA in December 1998. The main goal of Stage 1 D/DBPR is to reduce disinfectant demand and total disinfectant concentration, which in turn will reduce the concentration of potentially harmful disinfection byproducts that are formed by the reaction of chlorine with organic materials. The byproducts of concern include total trihalomethanes, total haloacetic acids, chlorite and bromate. The Stage 1 D/DBPR sets the maximum contaminant levels (MCL) for total trihalomethanes (TTHMs) and the sum of five haloacetic acids (HAA5) at 80 and 60 μg/l, respectively. The Stage 1 D/DBPR was effective as of February 1999, and large surface water systems (systems serving 10,000 or more people) must be in compliance by December 16, 2001.

Under Stage 2 of this rule, which may be promulgated as early as May 2002, the maximum contaminant levels for TTHMs and HAA5 may be reduced to 40 and 30 μg/l, respectively, with compliance anticipated by the year 2005.

This rule was promulgated via the "reg/neg" process, which allowed significant input from stakeholders and also allowed for risk/benefit and economic analysis. It is possible that the actual Stage 2 regulations will be significantly different than the 40 μg/l now being considered because of the reg/neg process and the high costs that would be required to meet the 40 μg/l standard.

The Water Company typically has trihalomethane (THM) levels, between 40 and 80 μg/l based on its current treatment process and disinfection with chlorine gas. Therefore, the potential exists for D/DBP levels in excess of the Stage 2 regulations if there are no changes made to the treatment process.

Generally D/DBP levels can be lowered in one of two ways. First, through removal of D/DBP precursor compounds (natural organic matter) using activated carbon or some membrane technologies. Secondly, by changing the points of chlorine application or changing the disinfectant used. Either, or both, of these methods may be required if the Stage 2 regulations are promulgated.

The available options for different disinfectants include ozone, ultraviolet radiation (UV) and chloramines. Each of these has different advantages and disadvantages. For instance, ozone is a very good oxidizer, which will effectively disinfect but provides no disinfectant residual to protect the water once it leaves the plant and enters the distribution system. Ozone systems are also quite expensive to construct and operate. UV has been used for many years as a wastewater disinfectant, however, this technology is relatively untested in the potable water market. UV, like ozone, provides no disinfectant residual. The use of chloramines is similar to the use of chlorine. They do provide a disinfectant residual. The Water Company formerly utilized chloramines as their primary disinfectant before the existing treatment plant was constructed.

2. Turbidity

Turbidity is a measure of the dispersion of light through a liquid. Turbidity is also an indicator of the amount of particles in a fluid. The Interim Enhanced Surface Water Treatment Rule (IESWTR), which was finalized in December 1998, requires combined filter effluent turbidities to be less than 0.3 nephelometric turbidity units (ntu) in 95 percent of samples taken and less than 1 ntu in 100 percent of samples taken. This rule was effective as of February 1999. Systems are required to establish a disinfection benchmark by March 2000 and must meet monitoring and reporting requirements for turbidity by December 2001.

The Water Company may have trouble meeting the lower standard especially during low temperature, high raw water turbidity events. Currently, low temperature water creates a situation where good quality floc formation is difficult. To gain better operational control of the high turbidity problem, CTE has evaluated and recommended changing the six existing filters from declining rate to constant rate variable level filters. The cost of these improvements are included in the cost analyses found in Chapter 8 for each of the alternatives. Another possible option would be to utilize a pre-sedimentation basin to reduce the influent turbidity to the clarifiers. Once the regulations governing backwash water recycle go into effect, the basin currently used to reclaim the backwash water could be utilized for this purpose. Other possible presedimentation basin locations include the current sludge lagoon site if alternative sludge disposal options can be accommodated or an existing strip of land at the treatment plant site.

3. Filter Backwash Recycle

The existing treatment plant practices recycling of filter backwash water. In other words, filter backwash waste is sent back to the head of the treatment plant to be retreated rather than "wasted." This practice was highly encouraged by the EPA from the 1970s to the 1990s due to the fact that filter backwash water can account for up to 10 percent of a plant's flow. This practice attempts to conserve valuable resources of water and electricity. However, recent events have demonstrated that the recycle practice may be undesirable from a water quality standpoint, as it reintroduces to the raw water constituents in a concentrated form, which have already been removed.

The Reauthorization of the Safe Drinking Water Act in 1996 specifically addresses this issue and requires new regulations on this subject by the year 2000. Conversations with several State Drinking Water Administrators, including Illinois, indicate that the backwash recycle regulations will be amended to limit the allowable percentage of backwash water that can be recycled and to require either some type of pretreatment of the recycled backwash water prior to reintroduction or discharge to a suitable disposal site (i.e. sanitary sewer).

The envisioned new regulations would require the Water Company to change its current recycle practice. Since 10 percent of total capacity going to waste represents a significant capacity loss and disposal cost, investigation of a treatment alternative such as sedimentation with or without coagulation, and/or some type of disinfection or a small microfiltration plant may be necessary once the future regulations are more clearly defined.

CHAPTER 6

EXISTING TREATMENT FACILITIES

A. DESCRIPTION OF UNIT PROCESSES

The existing CIWC treatment facility is a conventional facility utilizing the unit processes of chemical addition, softening, clarification, recarbonation, filtration and disinfection. The plant has a hydraulic capacity of approximately 14 mgd. Exhibit 6-1 is a site plan of the existing facilities.

Water from the North Fork of the Vermilion River is screened and pumped to the four circular reactor/clarifiers. Here lime and ferric chloride are added and mixed with the raw water and then allowed to settle. The lime raises the pH of the water which helps form a precipitate in the solution.

This removes the calcium and magnesium hardness from the solution in a solid state, thereby softening the water. The ferric chloride acts to agglomerate these particles into a floc which will settle by gravity in the clarifiers and can then be removed as sludge. The clarifiers can be operated in a series of two banks of two reactors each (typically spring, summer and fall operation) or in parallel as four separate reactors (only in winter).

There are typically three modes of operation at the plant:

1) Conventional
2) Herbicide and taste & odor removal
3) Treatment of high turbidity waters in winter and spring

The first mode includes ferric chloride application at the intake, two primary clarifiers used for lime softening, and two secondary clarifiers used as back-up clarifiers.

The second mode is similar to the first except that powdered activated carbon is added at the intake, and the two primary clarifiers are utilized only for contact time; the secondary clarifiers then provide lime softening and settling.

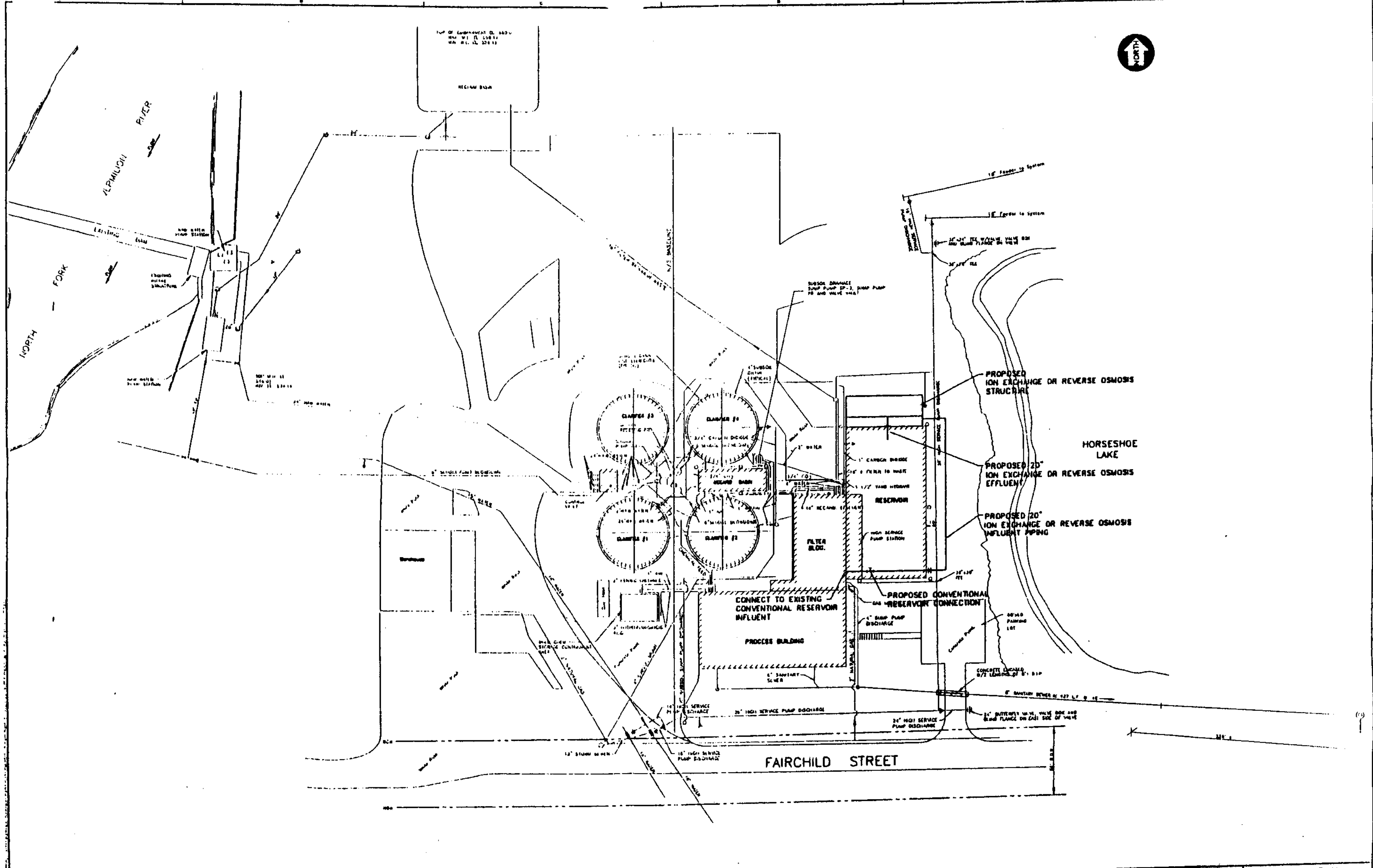
The last mode includes the application of ferric chloride at the intake and the utilization of all four clarifiers in parallel. This mode makes it difficult for personnel to properly split lime between the basins. This mode is required due the difficulty posed in removing sludge from the basins quickly enough.

From the clarifiers, the water is recarbonated by bubbling carbon dioxide through it in order to stabilize the water through pH adjustment.

After recarbonation, the water is sent to the conventional rapid sand filters to further remove any particulate contamination. The filters are comprised of six individual filter units, each equipped with air and surface wash capabilities to aid in cleaning. Water flows through a multimedia bed of sand, garnet and anthracite by gravity and is collected by an underdrain system for transport to the reservoir for disinfection, storage and high service pumping.

The filters are rated at up to 5 gallons per minute per square foot of surface area but are typically not run at those high rates.

After the water is filtered, it is disinfected using chlorine and then stored in the reservoir until it is pumped to distribution through the high service pumping system.



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PLANT SITE PLAN PROPOSED ION EXCHANGE OR REVERSE OSMOSIS SYSTEM	SHEET EXHIBIT 7-11	CTE PROJECT NO. 40184	

REVISIONS

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B. TREATMENT DIFFICULTIES

The following situations cause the operating personnel some difficulty in treating the raw water through the existing plant.

1. High flow, storm runoff in the spring with low alkalinity and hardness. There is not enough alkalinity and hardness for lime (only) softening to produce the desired hardness precipitates to weight the floc.

2. The Water Company has not had much success with polymer use either in coagulation or as a filter aid. They have tried anionic filter aid without much benefit and with shorter filter cycles resulting.

3. The daily plant load varies greatly in order to take advantage of off-peak power charges. This poses difficulty in operating with a sludge blanket in the clarifiers. When the load is increased, the sludge blanket expands (as expected) and may go over into the filters.

4. Storm events result in rapidly varying source water quality with increases in turbidity, SOC's, herbicides, and nitrates.

5. The clarifier upflow rate at design load (14 MGD) is 1.7 gpm/sf with two clarifiers in parallel. This is appropriate for lime softening but not for clarification alone. Per the 10 State Standards, the upflow rate shall not exceed 1.0 gpm/sf for units used for clarifiers and 1.75 gpm/sf for units used for softeners. Therefore, this eliminates the option of clarification without softening unless the four clarifiers are run in parallel.

C. OPERATIONAL CONSIDERATIONS TO EXPLORE

1. Color

- Start monitoring and recording the true color of the source water on a regular basis.

- It can be expected that the required ferric dose will be strongly influenced by the true color as well as by the turbidity. This has be shown to be true at many surface water softening plants. Monitoring the color will provide another measure of the required chemical dosage and allow the operator to make adjustments based on as much information as possible. In many cases, true color has proven to be a more accurate indicator of water quality than the other conventional parameters such as alkalinity and turbidity.

2. Magnesium as a Control Parameter

- Use a consistent caustic alkalinity (i.e., 2P-T) in the clarifier as a control parameter for the lime feed during softening. This should be used by all shift operators, even if settled water turbidity might imply that a lesser dose could be used.

- This should result in more consistent magnesium reduction with the $Mg(OH_2)$ precipitate acting as a flocculant and giving more consistent clarification.

- As an alternative, adopt a magnesium reduction goal to guide the lime feed. This may prove more difficult operationally because of the varying magnesium level in the raw water.

- SOC reduction is correlated with the magnesium reduction (see Thompson et al., JAWWA, June 1997, pp94-105), so the use of Mg as a control parameter may prove beneficial to the reduction in the TTHM potential and reduction in other DBP's.

3. Quality Control Issues

- If caustic alkalinity or magnesium are to be used in control decisions (as suggested above), it is important for the plant to institute some stringent quality control on those measurements. Both of these items involve the calculated difference between two titrated values. Thus, the chance for error is magnified if the two titrations are not performed with great care.

- A qualified individual should develop a quality control program for these parameters and instruct the operators in its importance and ensure that good practice is being followed.

4. Strategies During Low Alkalinity and Low Hardness in Source Water

- One option would be to run the four clarifiers in parallel for clarification without lime softening. Ferric and possibly a cationic polymer could be added at the intake, and coagulation would occur at a lower pH that would be more favorable for color removal. It would be necessary to raise the pH for corrosion control after clarification or following filtration. One disadvantage to this idea is the difficulty of switching from one mode to another as the source water changes fairly rapidly.

- Another option would be to add alkalinity to the source water so that softening reactions could continue in spite of low alkalinity and hardness in the source water. Alkalinity could be added using soda ash or lime plus CO_2. With either of these alternatives, the chemical(s) should be added to the mixing zone of the clarifier because precipitation of $CaCO_3$ would result, and it would be desirable for deposition to occur on the sludge in the reactor mixing zone rather than in the piping between the units. If Mg is low in the source water, the Water Plant would not have the advantage of forming much flocculant $Mg(OH)_2$ precipitate to aid in the flocculation of the fine $CaCO_3$ precipitate. Therefore, the ferric coagulant would be essential to the process in this circumstance. The advantage of this alternative is that the transition into and out of this mode would be rather quick and easy.

D. USE OF POLYMERS IN TREATMENT

Use of appropriate polymers is very common today. Cationics are common as partial substitutes for ferric or alum, serving as primary coagulants and are usually added at the same place in the flow scheme. Anionics are sometimes used as flocculant aids. Non-ionics are most commonly used for filter aids.

Use of polymers should be explored during troublesome treatment times using fresh polymer samples. The shelf life of polymer supplies recommended by the producer should be adhered to.

E. OPERATIONAL ISSUES

1. Filter To Waste

Currently, there is an uncertainty with the filter to waste flow rate. This will be addressed by installing a motor operated modulating valve on the 16-inch diameter filter to waste header, which will provide control of the filter to waste rate. The cost of this improvement is included in the cost analyses found in Chapter 8 for each of the alternatives.

2. Intake

Currently, the existing intake is a concrete shore intake structure with a stationary steel bar barrier to prevent the larger debris and flotsam from being drawn into the two 20-inch diameter raw water pump station suction lines. However, the existing intake structure causes treatment problems due to the passage of fish and debris through the steel bar barrier and into the raw water pump station suction lines. This issue was evaluated by CTE and based on their recommendation, two new 20-inch diameter surface water intakes will be installed with welded wire intake screens, and the existing intake structure will be kept for emergency use only. The cost of this improvement is included in the cost analyses found in Chapter 8 for each of the alternatives.

3. SCADA System

The existing Supervisory Control and Data Acquisition (SCADA) system is limited in its capabilities. Specifically, the current system is deficient in its ability to manipulate and archive data including the production of graphical displays. The trending of certain treatment parameters can only be produced using thermal strip chart plotters. The plotters present maintenance problems, and the thermal paper does not provide good data archiving. Therefore, based on evaluation and recommendations from CTE, improvements will be made to the SCADA System, which will include upgrading of the SCADA software and replacing the programmable logic controllers (PLC's) that will no longer be supported by the manufacturer due to obsolescence. The improvements will provide more meaningful data for better plant operations, as well as more information to regulators regarding treatment plant performance. The cost of the SCADA system improvements are included in the cost analyses found in Chapter 8 for each of the alternatives.

CHAPTER 7

ALTERNATIVE TREATMENT SCHEMES

A. INTRODUCTION

Based on the information previously presented, this chapter will enumerate and evaluate several viable treatment alternatives for the CIWC – Vermilion County Division. These alternatives utilize both surface water and groundwater as a sole and blended source and examine various modes of treatment of these waters.

B. DESIGN CRITERIA

The following table represents the major design criteria for the alternative solutions proposed.

TABLE 7-1
DESIGN CRITERIA

Water Quality Parameter	**Maximum Contaminant Level (MCL)**	**GOAL**
Effluent Nitrate (mg/l as N)	<10	<9
Turbidity (NTU)	<0.3	<0.2
Effluent THM (µg/l)	80	<40
Other Design Parameters	**Goal**	
Flow (mgd)	10.0	
Lake Vermilion Nitrate (mg/l as N)	12.7 (avg) 15.6 (max)	
Period of Nitrate Treatment (days) (Averaged over a 3 year Period)	90	

Additional criteria to be considered include capital, operation, and maintenance costs, waste disposal costs, and ease of operation. These criteria form the basis for comparing the alternatives to one another. The water quality goals, determined by maximum contaminant levels, are absolute. That is, any alternative not capable of meeting these goals cannot be considered further. On the other hand, the cost and operational criteria are relative costs that must be judged more subjectively.

The design criteria were developed utilizing historical plant data for the years of 1992 through 1999. In 1991, the level of the Lake Vermilion basin was raised, which altered the water quality of the lake by decreasing nitrate and turbidity levels. Therefore, plant data prior to 1992 was not used because it did not accurately represent the current water quality conditions. However, data from 1992 resulted in a 186 consecutive day period of high nitrate concentrations. Due to the raising of the dam in 1991, associated flooding, washing, and creation of wetlands occurred. When the new wetlands were allowed to develop, the nitrate levels decreased as the wetlands help to capture the nitrates before they reach the water source. Therefore, the 1992 data was not relied upon when determining the design criteria as it did not reflect the current nitrate situation. Instead, data from 1993 to 1999 was used to develop the design criteria regarding the required number of treatment days.

The nitrate concentrations for the historical period analyzed are shown graphically in Exhibits 7-1 through 7-8. From the graphical representations, the typical yearly nitrate trends include elevated levels during the late winter and early spring months lasting through the middle of June or beginning of July.

In the historical analysis, daily in-house nitrate readings are shown as opposed to the weekly IEPA nitrate data. The in-house nitrate levels were generally more conservative than the IEPA data showing higher peak nitrate concentrations, and the duration of high nitrate events were better defined by the more frequent nitrate readings.

The finished water flow was set at 10 mgd, which represents a value conservatively above the average daily flow during the periods of high nitrates. The finished water nitrate concentration of 10 mg/l is the maximum contaminant level allowed by law; therefore a goal of 9 mg/l or less was set to provide a margin of safety.

The Lake Vermilion nitrate concentrations of 12.7 and 15.6 mg/l, are the average and the maximum nitrate concentrations found during high nitrate events, respectively. Although the daily in-house readings show a maximum concentration of over 16 mg/l, based on consultation with the IEPA, a maximum nitrate concentration of 15.6 mg/l, as recorded by the IEPA was used for design purposes.

The annual period of operation represents the approximate total number of days per year on an annualized basis that the nitrate treatment alternative would be in operation. This value was set at 90 days averaged over a three year period, based on the total days per year with nitrate events of 9 mg/l or greater. Based on historical data, in certain years the nitrate treatment may not be operated at all, but in the following year it may be necessary to operate as frequent as 90 days. This value is reflective of data for the last few years of operation, which indicates a trend of less severe nitrate problems since the raising of the dam in 1992 and the creation of the wetlands. Additionally, CIWC has been working with the Lake Vermilion Water Quality Coalition (a water protection group whose purpose is to improve water quality in Lake Vermilion) to reduce the amount of nitrates that flow into the lake. See Table 7-2 for data showing the number of nitrate violations, the number of days duration of the violations and number of days with nitrate concentrations greater than 9.0 mg/l from 1993 to present. This can be contrasted with more severe nitrate problems in the five years prior to 1993. See Table 7-3 for the same data in the years 1988-1992.

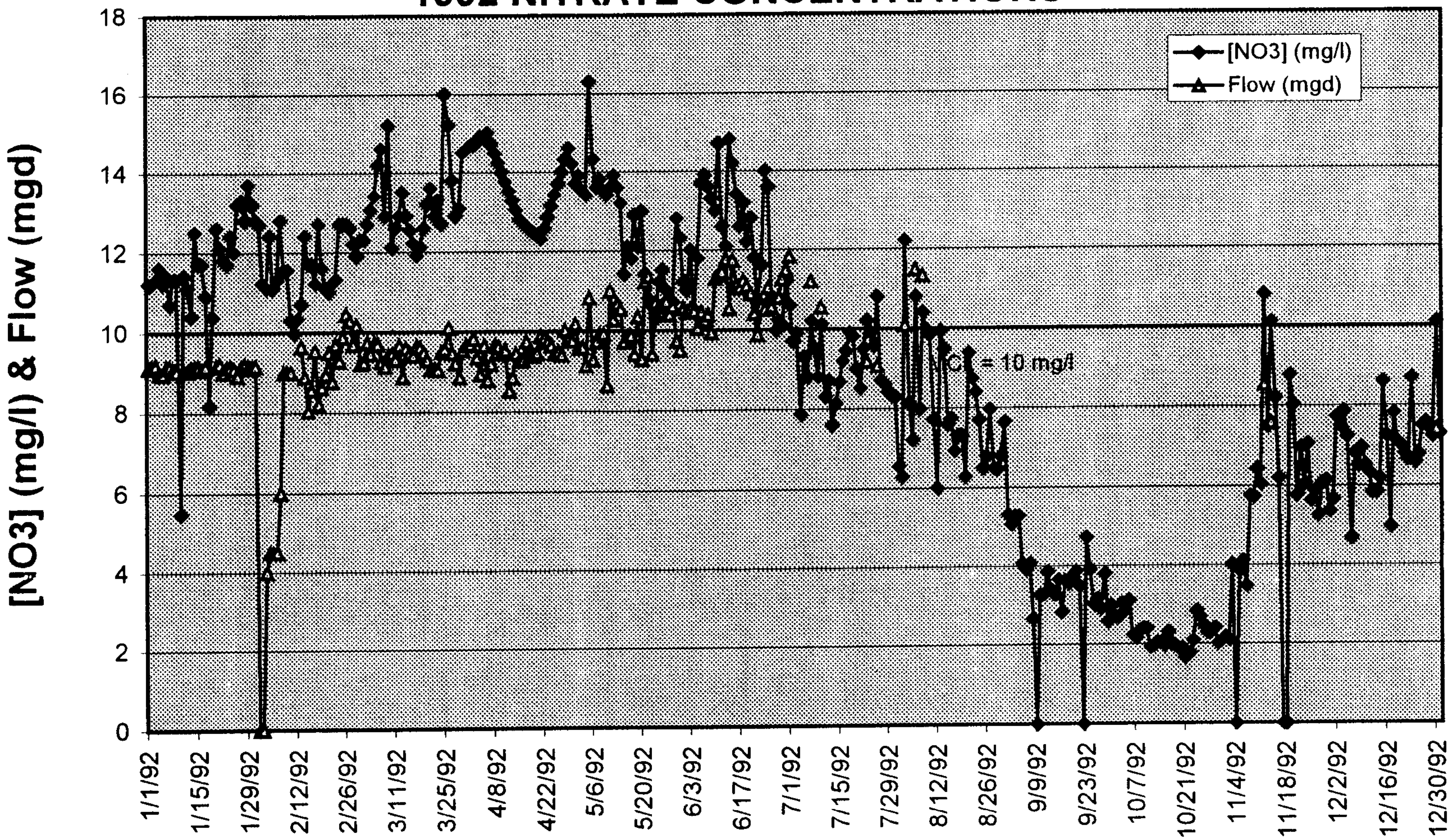
TABLE 7-2
NITRATE DATA
1993 – 1999

Year	No. of Violations	Days of Duration Violation(s)	No. of Days Above 9.0 mg/l
1993	0	0	0
1994	0	0	0
1995	0	0	1
1996	1	48	63
1997	1	7	21
1998	0	0	56
1999	2	21	91

TABLE 7-3
NITRATE DATA
1988 – 1992

Year	No. of Violations	Days of Duration Violation(s)	No. of Days Above 9.0 mg/l
1988	1	21	91
1989	1	148	168
1990	4	102	196
1991	2	20	98
1992	2	186	189

EXHIBIT 7-1
1992 NITRATE CONCENTRATIONS



NOTE: Daily in-house nitrate data was used for exhibit in lieu of the IEPA weekly data.

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